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Kinetic simulations of cosmic ray acceleration at shocks

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Hybrid particle in cell simulations (kinetic protons and fluid electrons) are providing us with unprecedented insights into the microphysics of collisionless shocks, also attesting to their ability to accelerate particles and to generate magnetic fields. I present state-of-the-art 2D and 3D simulations of non-relativistic shocks, discussing under which conditions (shock strength and inclination) ions are injected and energized via diffusive shock acceleration. I also show how resonant and non-resonant instability generate magnetic turbulence, and illustrate the energy spectrum of the self-generated turbulence. Finally, also exploiting the results of full PIC simulation, I present the first self-consistent description of how ions and electrons are injected into the acceleration process.

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